H3.

C2 cont.

18. (Amended) The reflowable solder bar recited by claim 17 wherein the conventional generally circular solder bumps have a particular solder pad diameter Dc, and wherein the diameter D of said first and second generally circular solder pads of said solder bar is in the range of from substantially Dc to substantially 2 times Dc.

19. (Amended) The reflowable solder bar recited by claim 17 wherein the conventional generally circular solder bumps have a particular solder bump volume Vc, and wherein the solder bar volume VB is in the range of from substantially 2 times Vc to substantially 5 times Vc.

20. (Amended) The reflowable solder bar recited by claim 16 wherein said first substrate is a flip-chip integrated circuit.

21. (Amended) The reflowable solder bar recited by claim 16 wherein any difference between height H2 and height H1 is less than 10% of height H2.

22. (Amended) The reflowable solder bar recited by claim 16 wherein any difference between height H2 and height H1 is less than 5% of height H2.

REMARKS

Claims 16-22 are pending for examination. Claims 16-22 have been amended above. A marked-up copy of the amended claims showing the changes being made is set forth in Attachment 1 hereto. Reexamination of this application, and reconsideration of the rejections of claims 16-22 is respectfully requested in view of the foregoing claim amendments, and in view of the following remarks.

Within Paragraphs 1-3 of the Office Action, the Examiner rejected claim 16, and dependent claims 17-22, under 35 U.S.C. §112, first paragraph; more specifically, the Examiner contends that Applicants did not originally disclose "the solder bar or the mass of the solder bar being made of a low melting temperature reflowable solder". As noted in Applicant's Amendment filed on October 24, 2002, Applicants' original disclosure, at page 1, line 27, describes a "63 Sn/37 Pb flip chip solder bump." Those skilled in the art have long

recognized that a 63/37 tin/lead alloy solder is a "low melting temperature solder." For example, U.S. Patent No. 5,796,169 (Dockerty, et al.), which has been applied by the Patent Examiner to reject the pending claims, discloses that 37/63 lead/tin alloy solder is a "low melting temperature solder." In addition, at page 12, lines 9-17, Applicants' specification discusses modeled mean time to failure for solder bumps, and for Applicants' solder bar, relative to the September 1998 technical article by Brandenburg, et al., "Electromigration Studies Of Flip Chip Bump Solder Joints", *Proceedings Surface Mount International*, September 1998; a copy of such article was provided to the Examiner along with Applicants' Disclosure Statement filed in this application. That article explains that the tested flip chip bump structure consisted of a eutectic Sn-Pb solder bump; see Brandenburg's description of Fig. 3 therein. It is well known in the art that "eutectic Sn-Pb solder" is a low melting temperature reflowable solder". Accordingly, those skilled in the art would have known immediately, by reading Applicants' original disclosure, that Applicants' solder bar structure consists of low melting temperature reflowable solder.

Within Paragraphs 4 and 5 of the Office Action, the Examiner rejected claims 16, and claims 17-22, under 35 U.S.C. §112, second paragraph, as being indefinite for failing to distinctly claim the invention; in this regard, the Examiner contends that the lower most base region of the solder mass is ambiguous. Claim 16 has been amended above to recite that the mass of low melting temperature reflowable solder has a lowermost base region adjacent said solder bar pad. If the location of the "lowermost base region" of the solder mass recited by claim 16 was previously ambiguous, any such ambiguity no longer exists.

Within Paragraph 6 of the Office Action, the Examiner contends that the word "apparatus" in dependent claims 17-22 lacks sufficient antecedent basis. Accordingly, Applicants have amended dependent claims 17-22 to refer to the "reflowable solder bar" recited in line 1 of claim 16.

Within the Office Action, the Examiner maintained the prior rejection of pending claims 16-22 under Section 103 as being considered obvious from U.S. Patent No. 5,796,169 to Dockerty, et al. (hereinafter, "Dockerty") in view of U.S. Patent No. 6,091,155 (Jonaidi);

U.S. Patent No. 6,050,832 (Lee); 6,118,182 (Barrow); and U.S. Patent No. 5,011,066 (Thompson).

Claim 16 recites that the mass of reflowable solder formed over the first and second generally circular solder pads and over the solder bar pad to form the reflowable solder bar is a mass of low melting temperature reflowable solder. In contrast, Dockerty specifically states that his support solder (16, 17 and 18) and solder balls (11) are formed of 90/10 lead/tin high melting temperature solder; see Dockerty, col. 3, lines 57-63, and col. 4, lines 51-65. Dockerty uses low melting temperature solder (20) only to attach the high melting temperature solder balls (11) and support solder (16, 17, 18) to underlying bond pads (4 and 15, respectively), as shown in Dockerty's Fig. 4. Likewise, when Dockerty's integrated circuit is to be joined to a mounting substrate (e.g., printed circuit board 1 of Fig. 5), low melting temperature solder paste is printed onto the circuit board contacts, the pre-formed solder balls and support solder are inserted into such solder paste, and the assembly is then heated to the reflow temperature of the low melting temperature solder paste to form the final attachment of the solder balls and support solder to the printed circuit board. Dockerty never describes any step of heating the high melting temperature support solder to its reflow temperature; indeed, such would degrade the ability of Dockerty's "support solder" to maintain a fixed cross-sectional dimension that matches the fixed cross-sectional dimension of Dockerty's solder balls, and would compromise Dockerty's objective of providing structural reinforcement to withstand thermal and physical stress.

Thus, Dockerty neither discloses nor suggests the formation of a reflowable solder bar having a mass of low melting temperature reflowable solder formed over first and second generally circular solder pads and over a connecting solder bar pad, in the manner claimed by claim 16 of the present application.

Claim 16 recites that the solder bar pad over which the solder bar is formed has a bar width BW that is less than the diameter D of the first and second generally circular solder pads. Claim 16 also recites that the mass of low melting temperature reflowable solder has a lowermost base region adjacent the solder bar pad of a width substantially equal to solder bar

pad width BW, and hence, also less than diameter D.

The Examiner concedes on page 4 of the Office Action that the principal reference Dockerty does not disclose the value of BW (solder bar pad width) being less than D (diameter of the circular solder end pads). Indeed, Dockerty stresses the importance of matching the cross-section of the support solder (at least along one axis) to the cross-section of the solder balls; see, for example, col. 2, lines 18-22; col. 2, lines 32-36; col. 2, lines 48-51; and particularly, col. 2, lines 54-59. Dockerty states that a "key structural feature" of Dockerty's structure is that the cross section of the support solder matches the cross section of the solder balls. Dockerty's requirement for such matching of such cross-sections is directly contrary to the limitations of claim 16 requiring that the solder bar pad width BW, as well as the width of the base region of the solder mass overlying the solder bar pad, be less than the diameter D of the generally circular end pads.

The Examiner contends that it would have been obvious to modify the Dockerty solder support structure to make the cross-sectional bar width of support solder 16, 17, 18 less than the diameter of solder balls 11, and less than the diameter of the circular end points of such support solder structures. On page 6 of the Office Action, the Examiner contends that such a modification of Dockerty would have been suggested by Jonaidi (No. 6,091,155).

Jonaidi is directed to BGA land patterns. The pads (14, 18) and connective traces (20) referenced by the Patent Examiner are not masses of solder; rather, they are printed conductive elements of a printed circuit board. Indeed, Jonaidi discloses that intermediate connecting region 20 includes a "solder mask dam" specifically to prevent solder from diffusing between landing pad 18 and capture pad 14; see Jonaidi, col. 3, lines 19-29. Accordingly, the teachings of Jonaidi are inherently inconsistent with, and contradict, Dockerty's teachings of an elongated solder support structure. Even if one skilled in the art were to apply Jonaidi's teachings to the Dockerty structure, the narrow connecting regions 20 would not have a mass of solder secured thereto.

The Patent Examiner has made specific reference to elements 233 and "pads" 228 and 230 of the cited patent to Lee. As shown in Fig. 3B of Lee, element 228 is not a "pad" but a

via conductor; see Lee, col. 7, lines 1-2. Conductive traces 233 of Lee are clearly not solder masses, in contrast to solder balls 12 and 16, which clearly are solder masses. Thus, Lee would not suggest to one skilled in the art to alter the dimensions of the Dockerty support solder, particularly when Dockerty stresses the importance of keeping the support solder cross-section equal to the solder ball cross-section.

On page 6 of the Office Action, the Examiner contends that the dimensions of D, H1, H2, BW, BL, and solder bump volume VB are all matters of "routine experimentation and optimization". However, the Examiner is simply choosing to ignore Dockerty's specific teaching that matching the cross-section of the support solder to that of any solder ball is the "key structural feature" (see Dockerty, Summary of the Invention", col. 2, lines 54-56).

On page 7 of the Office Action, the Examiner also relies upon Barrow as disclosing a "solder joint/bar (26 in Fig. 5)" having a width that is less than rectangular end pads (18 in Fig. 5). Applicants concede that Barrow discloses a solder joint 26 spanning two rectangular contact pads 18. However, Barrow lacks any solder bar pad connecting the two rectangular end pads under the central solder mass 26. It is not seen how the elimination of a connecting solder pad, or how the use of rectangular end pads, suggests any modification of Dockerty as would provide Applicants' claimed invention. More significantly, any narrowing of the cross section of the solder mass in its central region between the end pads, as taught by Barrow, would violate the primary objective of Dockerty, namely, to keep the cross section along the axis of the support solder matched to that of any solder ball 11; see Dockerty, col. 4, lines 51-56.

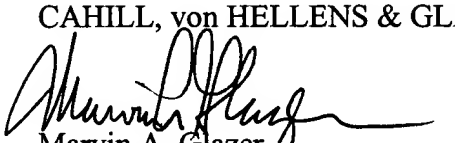
On page 7 of the Office Action, the Examiner also argues that the Thompson patent discloses a "flattened solder mass/joint (206 in Fig. 2C)". This argument is not believed to be relevant. Like Barrow, Thompson does not disclose circular solder pads and a connecting solder bar pad formed upon the same substrate. Moreover, in Thompson, the flattened solder mass 206 is circular (it wets to outer ring 204 of Fig. 2A during reflow), and fails to resemble a solder bar in any manner.

For the reasons set forth above, claims 16-22 define subject matter that would not have

been obvious to those skilled in the art based upon the art cited by the Examiner. Accordingly, Applicants respectfully submit that the present application should now be allowed.

Respectfully submitted,

CAHILL, von HELLENS & GLAZER, P.L.C.



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ATTACHMENT 1
Marked-Up Version of Claim 16, and Claims 17-22
for U.S. Patent Appl. Serial 09/575,298

16. (Three Times Amended) A reflowable solder bar formed upon an upper surface of a first substrate, the first substrate having a first electrical contact, said reflowable solder bar being adapted to join the first electrical contact to a second electrical contact on a second substrate, said reflowable solder bar comprising in combination:

a. a first generally circular solder pad formed upon the upper surface of the first substrate, the first generally circular solder pad having a center, and having a first predetermined diameter D;

b. a second generally circular solder pad formed upon the upper surface of the first substrate, the second generally circular solder pad having a center, and having said first predetermined diameter D, the center of said second generally circular solder pad being spaced from the center of said first generally circular solder pad by a predetermined spacing distance BL;

c. a solder bar pad of a first predetermined bar width BW formed upon the upper surface of the first substrate connecting said first circular solder pad to said second circular solder pad, the first predetermined bar width BW being less than the first predetermined diameter D;

d. a mass of low melting temperature reflowable solder having a solder bar volume VB formed over the first and second generally circular solder pads and over said solder bar pad to form said reflowable solder bar, the solder bar volume VB reaching a height H1 above the centers of said first and second generally circular solder pads, and reaching a height H2 above a midpoint of said solder bar pad, the mass of low melting temperature reflowable solder having a lowermost base region <u>adjacent said solder bar pad</u>, the width of the lower most base region of the solder mass along the solder bar pad being substantially equal to solder bar pad width BW;

e. wherein the values for predetermined diameter D, spacing distance BL, predetermined bar width BW, and solder bar volume VB are selected in such manner that H1 and H2 are approximately equal.

17. (Amended) The [apparatus] <u>reflowable solder bar</u> recited by claim 16 wherein conventional generally circular (as viewed from above) solder bumps are also formed upon the

upper surface of the first substrate, the conventional generally circular solder bumps having a height H3, and wherein height H1 and height H2 of said solder bar are approximately equal to height H3.

18. (Amended) The [apparatus] reflowable solder bar recited by claim 17 wherein the conventional generally circular solder bumps have a particular solder pad diameter Dc, and wherein the diameter D of said first and second generally circular solder pads of said solder bar is in the range of from substantially Dc to substantially 2 times Dc.

19. (Amended) The [apparatus] reflowable solder bar recited by claim 17 wherein the conventional generally circular solder bumps have a particular solder bump volume Vc, and wherein the solder bar volume VB is in the range of from substantially 2 times Vc to substantially 5 times Vc.

20. (Amended) The [apparatus] reflowable solder bar recited by claim 16 wherein said first substrate is a flip-chip integrated circuit.

21. (Amended) The [apparatus] reflowable solder bar recited by claim 16 wherein any difference between height H2 and height H1 is less than 10% of height H2.

22. (Amended) The [apparatus] reflowable solder bar recited by claim 16 wherein any difference between height H2 and height H1 is less than 5% of height H2.